

20 April 1966

TECP 700-700
Materiel Test Procedure 3-2-702*
Aberdeen Proving GroundU. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

OPTICAL RANGE FINDERS

AD717543

1. OBJECTIVE

→ The objective of this procedure is to determine range finder performance with respect to precision, compatibility, stability and effectiveness.

2. BACKGROUND

→ In tank gunnery, there are many sources of error which limit the overall accuracy attainable with the gun-ammunition-fire control system. Among these errors, visual range estimation predominates as a major contributor to inaccuracy. To reduce or minimize range error effects, range-finding devices are installed in combat vehicles. Appendix A contains a discussion of the basic types of range finders considered for combat vehicles.

3. REQUIRED EQUIPMENT

a. Adequate Test Areas:

- 1) Minimum range of 5000 meters
- 2) Stabilization courses as described in MTP 3-2-602
- 3) Slope-level-slope areas for uniformity testing

b. Applicable Test Vehicle with gun/gunsight system

c. Combat Type Targets:

- 1) Vehicles
- 2) Simulated gun emplacements
- 3) Bunkers
- 4) Buildings

4. REFERENCES

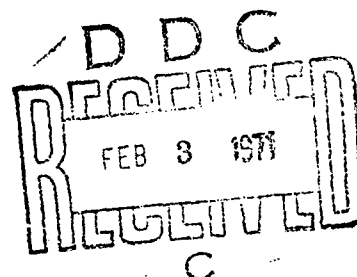
- | | | |
|----|-------------|--|
| A. | MTP 2-2-620 | <u>Resistance to Severe Shock</u> |
| B. | MTP 2-2-803 | <u>Human Engineering</u> |
| C. | MTP 3-2-602 | <u>Stabilization Systems</u> |
| D. | MTP 3-2-604 | <u>Boresight Retention</u> |
| E. | MTP 3-2-605 | <u>Accuracy Firing of Vehicular Mounted Weapons</u> |
| F. | MTP 3-2-700 | <u>Superelevation-Range Relationship of Ballistic Mechanisms</u> |
| G. | MTP 3-2-701 | <u>Sight Parallelogram Error</u> |
| H. | MTP 3-2-814 | <u>Optical Collimation of Range Finders</u> |
| I. | MTP 3-2-828 | <u>Statistical Aids</u> |

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5.1 SUMMARY

This MTP describes the following tests which are conducted to evaluate range finding devices and the factors that influence their accuracy and precision.

- a. Internal Correction System (ICS) Tests - A determination of the deviation of the ICS range value from the true range value.
- b. Uniformity tests - a determination of the uniformity of range results over the weapons entire field of view and limits of gun elevation and depression.
- c. Accuracy Performance Tests - A determination of the gun-gunner-range finder combination under ideal conditions, and simulated combat conditions.
- d. Ranging Tests - A determination of the ability of an operator-range finder to obtain accurate range readings, within the specified amount of time, under various conditions: stationary target-moving test vehicle, moving target - stationary vehicle, night time conditions.
- e. Durability, Utility and Shock Studies - A determination of the ability of pilot model equipment to operate successfully after being subject to prolonged operation under realistic conditions.

6.2 LIMITATIONS

This procedure is limited to tank-installed optical range finders. For background information purposes, non-optical range finders are discussed, along with optical range finders, in Appendix A.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Pre-Scheduling Conditions

- a. Experienced tank gunnery personnel shall be available in order to minimize test time, assure qualitative data, and reduce training time for new equipment. Appendix B describes operator requirements and training methods.
- b. Insure the availability of a test site that allows for a varied background (trees, buildings, sky, hills) and can accommodate the maximum anticipated range of engagement.
- c. Insure that a sufficient number of varied targets (vehicles, simulated gun emplacements, bunkers, etc.) at predetermined distances (measured to 0.25% accuracy) are available.

6.1.2 Preparation of the Test Item

- a. Range finder collimation shall be checked as described in MTP 3-2-814.
- b. Adjust the following to requirements of the range finder operator:

- 1) Diopter setting
- 2) Inter-pupillary distance
- 3) "Halving"

4) Brow pad position

c. Where applicable, insure proper performance of related mechanisms involving:

- 1) Turret power control
- 2) Ballistic mechanism as described in MTP 3-2-700
- 3) Boresight accuracy as described in MTP 3-2-604
- 4) Sight parallelogram errors as described in MTP 3-2-701

6.2 TEST CONDUCT

During the conduct of the procedures described below the following shall be recorded:

- a. Operator's name and experience.
- b. Temperature, hourly, in degrees F.
- c. Relative humidity, each hour, in percent.

6.2.1 Internal Correction System (ICS) Tests

Internal Correction System range data deviation from true range shall be determined as follows:

- a. Select a clearly defined target at a range of 1500 meters.
- b. Set the range finder scale to the true range value.

NOTE: Use extreme care in reading range scales to preclude invalid test results caused by inaccurate readings.

c. Obtain stereo contact or coincidence (depending upon the instrument used. See Appendix A) five times using the ICS knob and reading the range scale.

d. Set the mean ICS value on the range scale and obtain stereo contact or coincidence (as applicable) five times using the range knob and reading the range scale.

e. Compute the true range (mean value of step d).

f. Verify the ICS linearity by immediately performing the following:

- 1) Select a clearly defined target at a range of 2000 meters.
- 2) Compute the mean range scale reading by obtaining stereo contact or coincidence five times using the range knob and reading the range scale.
- 3) Select a clearly defined target at a range of 3000 meters.
- 4) Repeat step 2.
- 5) Select a clearly defined target at a range of 1000 meters.
- 6) Repeat step 2.
- 7) Select a clearly defined target at a range of 500 meters.
- 8) Repeat step 2

g. Repeat steps a through f until a minimum of 3 operators have performed the test.

6.2.2 Uniformity Tests

6.2.2.1 Field of View

The field of view uniformity test, primarily conducted on coincident type range finders, shall be performed as follows:

- a. Select two clearly defined targets at ranges of 1000 and 2000 meters.
- b. Divide the test items field of view into segments as indicated in Figure 1.
- c. Obtain five range readings with the target located in each section of the field of view. Compute the mean range for each section.
- d. Repeat steps a through c until a minimum of 3 operators have performed the test.

6.2.2.2 Precision of the De-Rotating Prisms

The de-rotating prism precision test, for test items having fixed eye-pieces, which is conducted to determine prism capability to maintain uniformity in range results throughout the limits of gun elevation and depression, shall be performed as follows:

- a. Select a clearly defined target at 1000 meters.
- b. With the tank level (line of sight essentially zero), as shown in Figure 2, obtain an ICS adjustment and confirm the test item range accuracy.
- c. Elevate the gun five degrees.
- d. Slowly move the vehicle forward, down the slope (see Figure 2) until the gun is on the target of step a.
- e. Obtain five range readings and compute the mean range value.
- f. Elevate the gun five degrees.
- g. Repeat steps d and e.
- h. Repeat steps f and g until the maximum gun elevation is obtained.
- i. Return the test vehicle and item to the position of step b.
- j. Depress the gun five degrees.
- k. Slowly move the vehicle backward, down the slope (see Figure 2) until the gun is on the target of step a.
- l. Obtain five range readings and compute the mean range value.
- m. Depress the gun five degrees.
- n. Repeat steps k and l.
- p. Repeat steps m and n until the maximum gun depression is obtained.
- q. Repeat steps a through q until a minimum of 3 operators have performed the test.

6.2.3 Accuracy Performance Tests

6.2.3.1 Precision Tests

Precision accuracy tests, conducted to determine if production test items meet standards, shall be performed as follows:

- a. Ensure that the test item is in proper operating condition.
- b. Select clearly defined targets at ranges of 500 meters to the maximum range capability of the test item, spaced 500 meters apart.
- c. Obtain range readings a total of 5 times on each target.

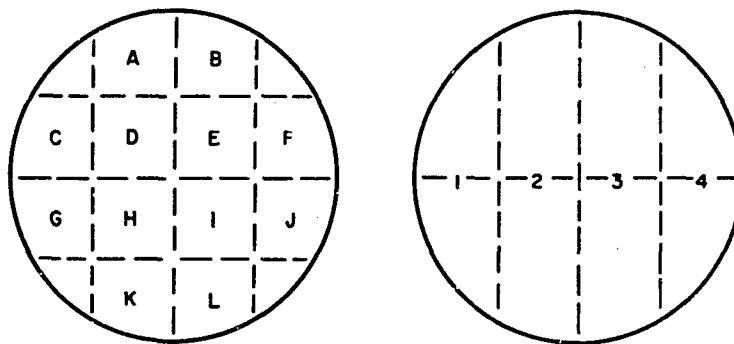


FIGURE 1. TYPES OF COINCIDENCE TEST AREAS

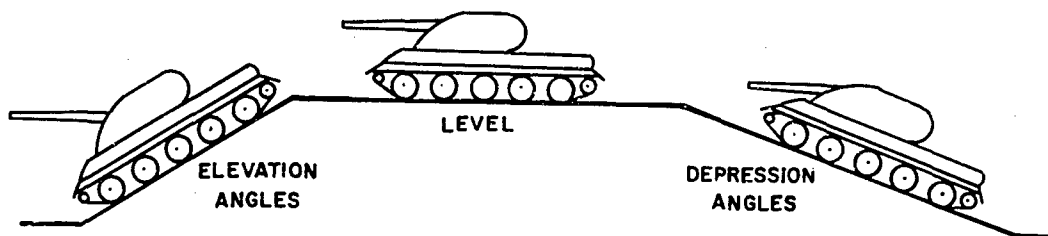


FIGURE 2. POSITIONING VEHICLES FOR VARIOUS ANGLES OF ELEVATION

d. Repeat steps a through c until a minimum of 3 operators have performed the test.

6.2.3.2 Simulated Combat Tests

Simulated combat tests are performed to determine, within the limits of the available equipment and facilities, instrument accuracy performance under simulated field conditions.

Tests shall be conducted as described in the Utility of Operation Section of MTP 3-2-605 with the following additions:

a. Accuracy firing shall be extended over a sufficiently long period to encompass a representative cross section of weather conditions.

b. Targets shall be representative of those encountered in the field, and the background shall be changed frequently.

c. A minimum of 3 operators shall operate the test item during testing.

6.2.4 Ranging Tests

6.2.4.1 Stabilized Conditions

Ranging, under stabilized conditions is performed to determine the ability of the operator - test item combination to accurately indicate target range while the test item is moving over the standard stabilizer courses of MTP 3-2-602.

a. Prepare the stabilizer courses, of MTP 3-2-602, by installing markers which shall indicate course position-to-target distance within one meter for each 50 meters of distance closing, commencing with a distance of 1450 meters distance down to 500 meters distance.

b. Operate the test vehicle at the speed indicated for the stabilized courses of MTP 3-2-602 and take range distance each minute commencing with vehicle start up. Test shall be performed 3 times by a minimum of 3 different operators.

c. Record the following:

- 1) Course used
- 2) Vehicle velocity
- 3) Test item indicated range, each minute
- 4) True target range as indicated by markers
- 5) Run number
- 6) Operator

6.2.4.2 Moving Targets

Ranging on moving targets is performed to determine the ability of the operator - test item combination to accurately indicate target range when tracking moving targets from a stationary test vehicle. The test shall be performed 3 times by a minimum of 3 different operators.

Perform the following:

- a. Set a mobile target in a stationary position at a true range of 1500 meters.
- b. Record the range, and time required to determine the range, as obtained by the test item sighting on the target.
- c. Vary the target speed (from 0-to-30 miles per hour) and aspect (direction of motion with respect to the test item) at predetermined rates, and record the range and time required to determine the range every 5 minutes for a period of 30 minutes.

NOTE: Target speed and aspect sequence shall be different for each operator.

- d. Record problems noted in sensing stereoscopic contact or superimposition of images.

6.2.4.3 Night Tests

Ranging during the night is performed to determine accuracy deterioration caused by reduced lighting and the effects of test item lighting.

- a. Prepare clearly defined targets at 500-meter intervals from a range of 500 meters to the maximum range capability of the test item.

NOTE: Each "range" shall have 3 dissimilar targets, no closer than 5 degrees from each other to prevent operator memory from interfering with the objectives of the test.

- b. Commencing with late afternoon and continuing through dusk, and for a minimum of two hours after sunset range data shall be obtained as follows:

- 1) One operator shall take 5 complete sets of data (one set consisting of one target at each of the ranges) and be followed by two or more operators who shall also take 5 complete sets of data.

NOTE: No two consecutive data runs shall be similar. The range sequence and target at a given range for each run shall be varied.

- 2) Sufficient operators shall be on hand to insure that no one operator shall become fatigued.

- c. Record the following:

- 1) Time of testing
- 2) Operators set number
- 3) Test set number
- 4) Range obtained for each target
- 5) Target for the given range
- 6) Target background

- d. Determine the following:

- 1) Effect of reticle illumination characteristics

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- 2) Influence of internal light reflections
- 3) Presence of "ghosts"
- 4) Eye accommodation to darkness
- 5) Human engineering aspects of MTP 2-2-803 have been

accomplished

6.2.5 Durability, Utility, and Firing Shock Studies

6.2.5.1 Pre-Test Operation:

- a. Mount the test item in a vehicle having a gun/gunsight system
- b. Verify optical collimation as described in MTP 3-2-814
- c. Verify boresight retention as described in MTP 3-2-604
- d. Determine ballistic mechanism accuracy as described in MTP

3-2-700

- e. Determine sight parallelogram errors as described in MTP 3-2-701

6.2.5.2 Durability, Utility and Shock Tests

- a. Check the accuracy of the test items gun-gunsight-operator combination by performing the Utility of Operation section of MTP 3-2-605
- b. Subject the test vehicle, and its mounted equipment, to the shock tests described in MTP 2-2-620.

6.2.5.3 Post-Test Checks

At the completion of paragraph 6.2.5.2 perform the following:

- a. Firing checks as described in the Utility of Operation section of MTP 3-2-605
- b. Optical collimation of the test item as described in MTP 3-2-814

6.3 TEST DATA

6.3.1 Preparation for Test

Record the following:

- a. Type of range finder under test (stereoscope, full field superimposed coincidence, etc.)
- b. Optical collimation data as collected in MTP 3-2-814
- c. Ballistic mechanism data as collected in MTP 3-2-700
- d. Boresight accuracy data as collected in MTP 3-2-604
- e. Sight parallelogram error data as collected in MTP 3-2-701

6.3.2 Determination of Internal Correction System (ICS)

Record the following:

- a. Operators name and experience (training and active time, in hours)
- b. Temperature, each hour, in °F
- c. Relative humidity, each hour, during ICS test in percent
- d. At 1500 meters

- 1) Computed mean ICS range in meters
 - 2) Computed true range in meters
- e. ICS linearity check mean range, in meters, at:
- 1) 2000 meters
 - 2) 3000 meters
 - 3) 1000 meters
 - 4) 500 meters

6.3.3 Uniformity Tests

6.3.3.1 Field of View

Record the following:

- a. Field of view segments used (numerical or alphabetical)
- b. Operators name and experience (training and active time, in hours)
- c. Temperature, each hour, in °F
- d. Relative humidity, each hour, in percent
- e. Mean range distance, in meters, for:
 - 1) 1000-meter target in each field of view segment
 - 2) 2000-meter target in each field of view segment

6.3.3.2 De-Rotating Prisms

Record the following:

- a. Operators name and experience (training and active time, in hours)
- b. Temperature, each hour, in °F
- c. Relative humidity, each hour, in percent
- d. Range determination, at zero line of sight, in meters
- e. For gun elevation:
 - 1) Gun elevation angle, in degrees
 - 2) Mean range determination, in meters
- f. For gun depression:
 - 1) Gun depression angle, in degrees
 - 2) Mean range determination, in meters

6.3.4 Accuracy Tests

6.3.4.1 Precision Tests

Record the following:

- in hours)
- a. Operators name and experience (training and active time,
 - b. Temperature, each hour during precision tests, in °F
 - c. Relative humidity, each hour during precision tests, in percent
 - d. Mean range determined, for range distances used, in meters

6.3.4.2 Simulated Combat Tests

Record the following:

- a. Operators name and experience (training and active time, in hours)
- b. Temperature, each hour during simulated combat tests, in °F
- c. Relative humidity, each hour during simulated combat tests, in percent
- d. Targets encountered
- e. Data collected as described in the Utility of Operation section of MTP 3-2-605

6.3.5 Ranging Tests

6.3.5.1 Stabilized Conditions

Record the following:

- a. Operators name and experience (training and active time, in hours)
- b. Operators stabilized condition run number (1, 2, or 3)
- c. Temperature, each hour during stabilized condition tests, in °F
- d. Relative humidity, each hour during stabilized condition tests, in percent
- e. Course used
- f. Vehicle velocity, in miles per hour
- g. Test item indicated range, each minute, in meters
- h. True target range, each minute, in meters

6.3.5.2 Moving Targets

Record the following:

- a. Operators name and experience (training and active time, in hours)
- b. Operators stabilized condition run number (1, 2, or 3)
- c. Temperature, each hour during moving target tests, in °F
- d. Relative humidity, each hour during moving target tests, in percent
- e. For stationary target
 - 1) Test item indicated range, in meters
 - 2) Time required to obtain range, in seconds
- f. For moving targets:
 - 1) Range in meters
 - a) Indicated
 - b) True
 - 2) Time required to obtain range, in seconds
 - 3) Vehicle aspect (toward, away, to right, to left, away, left, etc.)

g. Problems encountered in sensing stereoscopic contact or superimposition of images.

6.3.5.3 Night Testing

Record the following:

hours) a. Operators name and experience (training and active time, in

b. Operators set number (1, 2, 3, 4, 5, ----10-----20 etc.)

c. Test set number (1-----100, etc.)

d. Temperature, each hour, in °F

e. Relative humidity, each hour, in percent

f. Time of test (month, day, hour, minute)

g. For each set:

1) True range, in meters

2) Obtained range, in meters (or indicate unobtainable)

3) Range target (tank, building, etc.)

4) Target background (sky, woods, etc.)

5) Effects of reticle illumination characteristics

6) Influence of internal light reflections

7) Presence of "ghosts"

8) Eye accommodation to darkness

h. Suitability of controls, etc. as described in MTP 2-2-803

6.3.6 Durability, Utility and Firing Shock Studies

6.3.6.1 Pre-Test Operation

a. Optical collimation data shall be recorded and collected as described in MTP 3-2-814.

b. Boresight retention data shall be recorded and collected as described in MTP 3-2-604.

c. Ballistic mechanism accuracy data shall be recorded and collected as described in MTP 3-2-700.

d. Sight parallelogram error data shall be recorded and collected as described in MTP 3-2-701.

6.3.6.2 Durability, Utility and Shock Tests

a. Firing data shall be recorded and collected as described in the Utility of Operation section of MTP 3-2-605.

b. Shock resistance data shall be recorded and collected as described in MTP 2-2-650.

6.3.6.3 Post-Test Checks

a. Firing data shall be recorded and collected as described in the Utility of Operation Section of MTP 3-2-605.

b. Optical Collimation data shall be recorded and collected as described in MTP 3-2-814.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 General

It is common practice to indicate optical range finder errors in "Units of Error" (UOE), a quantity which places the optical instruments on a comparative basis with respect to base length and magnification (see Figure 3).

When obtaining more than one range finder reading for a given range the individual readings taken for the computation of the mean shall not exceed 1% of the mean deviation of the true range distance.

Since the "UOE" computation includes range, its use permits averaging data over a variety of ranges, i.e. data obtained at 1000 meters are comparable with data recorded at 2000 meters, and so forth.

It has been assumed that the range estimates have a normal distribution (GAUSSIAN) about the true range. However, in a major test, data samples should be checked to insure that the distribution is not seriously skewed. MTP 3-2-828 indicates aids in making this analysis.

After translating the raw data obtained during the conduct of the test, and as an aid to the analysis, it is suggested that the project engineer have prepared and examine the following:

- a. A graph depicting the range error (UOE) versus true range as indicated in Example 1 of Figure 4.
- b. A graph depicting the percent of range error versus the true range as indicated in Example 2 of Figure 4.
- c. A graph depicting the consistency (UOE spread) of trainees versus training time when the procedures of this MTP are used for training purposes as indicated in Example 3 of Figure 4.
- d. A graph depicting the accuracy (range error in UOE) of trainees versus training time, when the procedures of this MTP are used for training purposes as indicated in Example 4 of Figure 4.
- e. A graph depicting, by percentage, the frequency of a given range estimate (range error-UOE) against the total number of estimates made, as indicated in Example 5 of Figure 4.

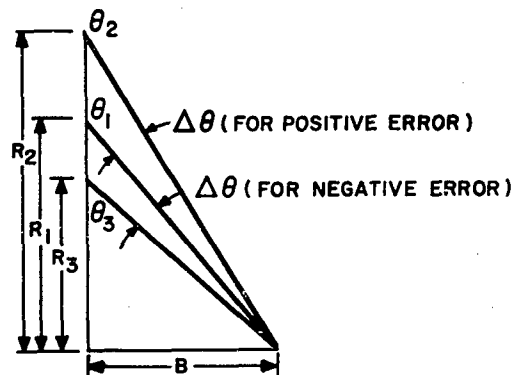


FIGURE 3. SKETCH SHOWING BASE FOR COMPUTATION OF UOE

Computation of UOE shall be accomplished as follows:

$$1 \text{ UOE} = \frac{d}{M}$$

$$\tan \theta_1 = \frac{B}{R_1} = \theta_1 (\text{in radians})^a$$

$$\tan \theta_2 = \frac{B}{R_2} = \theta_2$$

$$\tan \theta_3 = \frac{B}{R_3} = \theta_3$$

Where:

d = Disparity angle (12 seconds of arc)^b

M = Magnification

R = True range in meters

B = Base length of range finder in meters

R_2, R_3 = Observed range readings (or averages) in meters
($R_2 > R_1$ and $R_3 < R_1$)

For positive errors:

$$\Delta\theta = \theta_1 - \theta_2 \text{ or } \tan \Delta\theta = \tan \theta_1 - \tan \theta_2$$

$$\begin{aligned} \text{Total Error} &= \frac{\Delta\theta}{\text{in units of } \left(\frac{d}{M}\right)} \\ \text{UOE} &= \frac{\tan \Delta\theta}{\tan \left(\frac{d}{M}\right)} \end{aligned}$$

For negative errors:

$$\theta = \theta_1 - \theta_3$$

For example:

Range Finder, T31: Magnification - 10X
Base length - 2.74 meters

$$d = \frac{12 \text{ seconds}}{206,265 \text{ seconds per radian}} = 0.0000582 \text{ radian}$$

$$1 \text{ UOE} = \frac{d}{M} = \frac{0.0000582}{10} = 0.00000582 \text{ radian}$$

^aSince the angles involved are very small, $\tan \theta = \theta$, if θ is expressed in radians.

^bBased on the uncertainty of observation, an error is introduced in ranging by the operator himself. This error must be taken into consideration in evaluating the accuracy of the instrument. The average observational error among competent observers has been found to represent an angle of 12 seconds of arc at the eye (Ref. TM 9-1623).

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Assume:

$$R_1 = 1000 \text{ meters}$$

$$R_2 = 1050 \text{ meters}$$

Then:

$$\tan \theta_1 = \frac{2.74}{1000} = 0.00274$$

$$\tan \theta_2 = \frac{2.74}{1050} = 0.0026095$$

$$\Delta\theta = 0.00274 - 0.0026095 = 0.000131 \text{ radian}$$

$$\text{Error in UOE} = \frac{0.000131}{0.0000582} = 22.5$$

When errors are very small, less than 10 UOE, the following approximation may be used (with an accuracy of five percent or better).

$$\text{Meters per UOE} = \frac{(d) (R_1^2)}{(M) (B)}$$

$$\text{Error in UOE} = \frac{\text{Error in meters}}{\text{Meters per UOE}}$$

For example:

For the T31 range finder in the above example:

$$\text{Meters per UOE} = \frac{(0.0000582) (R_1^2)}{(10) (2.743)} = 2.124 \left(\frac{R_1}{1000} \right)^2$$

If:

$$R_1 = 1000 \text{ meters}$$

$$R_2 = 1010 \text{ meters}$$

$$\text{Error} = 10 \text{ meters}$$

Then:

$$\text{Meters per UOE} = 2.124 \left(\frac{1000}{1000} \right)^2 = 2.124$$

$$\text{Error in UOE} = \frac{10}{2.124} = 4.7$$

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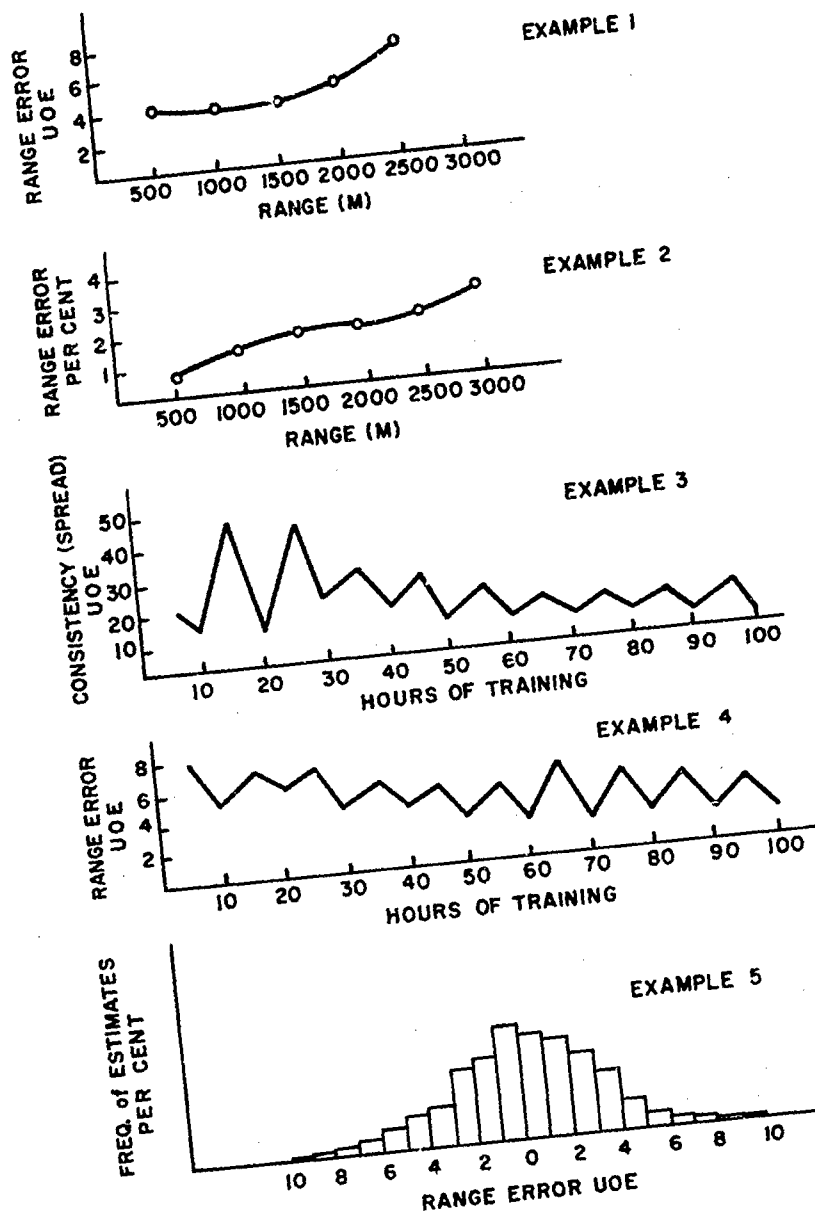


FIGURE 4. REPRESENTATIVE GRAPHS RESULTING FROM TESTS OF RANGE FINDING

6.4.2 Determination of Internal Correction System (ICS)

a. Determine the "UOE" of the true range at 1500 meters. Should the UOE be greater than "2" the procedure will have to be repeated. If the error, with two operators, remains above a "UOE" of "2", the testing shall be terminated until the cause of error is determined and eliminated, and the test shall be redone.

b. Determine the linearity of the ICS by plotting the ICS "UOE" against the true range value. If the resulting curve is not linear the test shall be terminated, the cause of error determined and eliminated, and the entire test redone.

6.4.3 Uniformity Tests

6.4.3.1 Field View

The mean readings of the individual sections of the field of view should have "UOE's" which are within 0.10 percent of each other. If the variations are greater, the test shall be suspended, the cause of error determined and eliminated, and the entire test redone.

6.4.3.2 De-Rotating Prisms

The mean obtained range reading at each angle shall be such as to result in an "UOE" having a maximum of "2".

6.4.4 Accuracy Tests

6.4.4.1 Precision

The UOE obtained from the obtained data shall be less than 0.5. If the unit of error is greater, the equipment shall be examined for defects and the operator's ability shall be checked on a known accurate range finder.

6.4.4.2 Simulated Combat

Data shall be reduced and presented as described in the Utility of Operation section of MTP 3-2-605.

6.4.5 Ranging Tests

6.4.5.1 Stabilized Conditions

The obtained range data shall have maximum "UOE" of "4". If the "UOE" is greater than "4" the position of the markers shall be re-examined to insure that their position is adequate for determining true range and the operator's ability verified on a known accurate range finder.

6.4.5.2 Moving Targets

The obtained range data shall have a maximum "UOE" of "2" for stationary target readings and a maximum unit of error of "4" for moving targets. If the "UOE" is greater than "4" the predetermined schedule shall be examined to insure that the "readings" were taken at the correct time, and the opera-

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tor's ability shall be verified on a known accurate range finder.

6.4.5.3 Night Tests

Graphs shall be prepared, depicting units of error versus light conditions, maximum usable ranges versus light condition.

6.4.6 Durability, Utility and Firing Shock Studies

The effects of resistance to shock tests on the range finder and the accuracy firing of the test vehicle weapon system shall be determined by comparing firing data, as analyzed in the Utility of Operation section of MTP 3-2-605 obtained after running resistance to shock tests with the results obtained prior to resistance to shock tests. Similarly the effect of the resistance to shock tests on the optical collimation of the range finder under test shall be determined by comparing post shock results with pre shock results.

6.4.7 Summary

The overall analysis by the project engineer should present the level of performance of the test item, the effects of operator proficiency, and the ability of the test item to increase the effectiveness (hit probability and time of first round on target) of the tank.

APPENDIX A

RANGE FINDER DESCRIPTION

Range finders usually fall into one of the following categories:

- a. Optical - which uses triangulation as a basis for range determination.
- b. Time-base - which uses the speed of light or electromagnetic radiation as a standard for determining distances.
- c. Subcaliber - trajectory matching

Of the many variations of the three basic types of range finders, the following are the primary versions considered for use in tanks:

- a. Stereoscopic - A binocular instrument in which an exaggerated sense of depth perception is used to position a stereoscopic pattern at the same apparent position in space as is occupied by the target. Figure A-1 illustrates this type of finder.

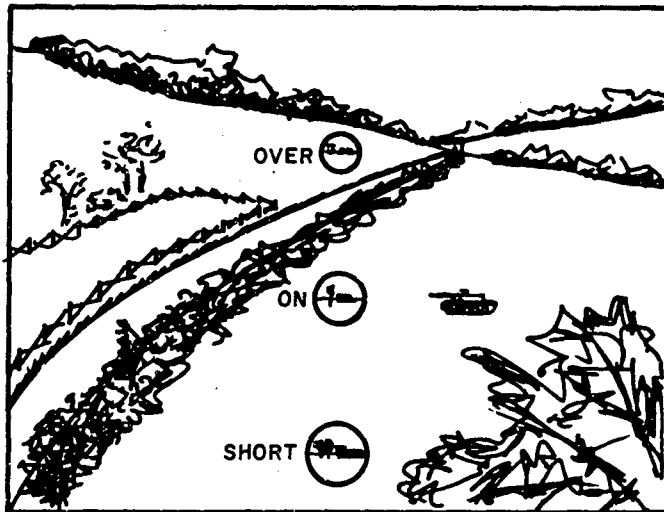


FIGURE A-1 STEREOSCOPIC PERCEPTION

- b. Full Field Superimposed Coincidence - A monocular instrument in which ranging is accomplished by superimposition of the fields of view of the right and left optical systems. As shown in Figure A-2 there is usually a difference in the secondary images because of the tinted optics used for one of the two systems.

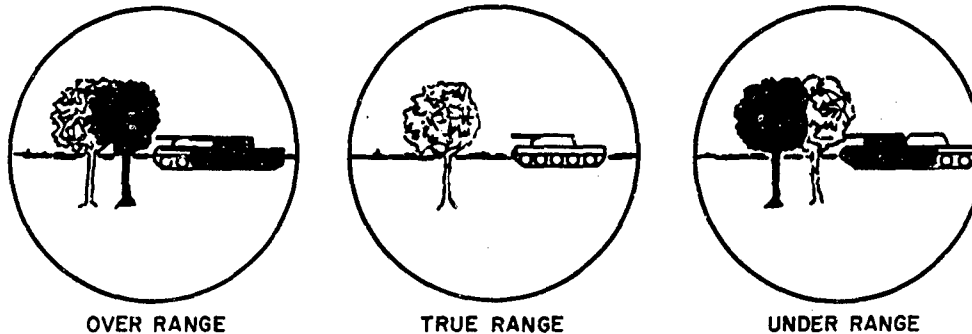


FIGURE A-2 FULL FIELD SUPERIMPOSED COINCIDENCE

c. Full Field Superimposed Coincidence with Flicker Assist - An instrument similar to the coincidence range finder shown in Figure A-2 with an aid for detecting exact superimposition. By alternately presenting the right and left fields of view to the operator's eye by a flickering shutter, the targets appear stationary only when they are exactly superimposed.

d. Split Field Coincidence - A monocular device in which the right and left fields of view are presented to the operator's eye in the upper and lower halves of the objective to form a single sight picture. Ranging is accomplished by aligning the two portions of the target along the split in the field. This operation is illustrated in Figure A-3.

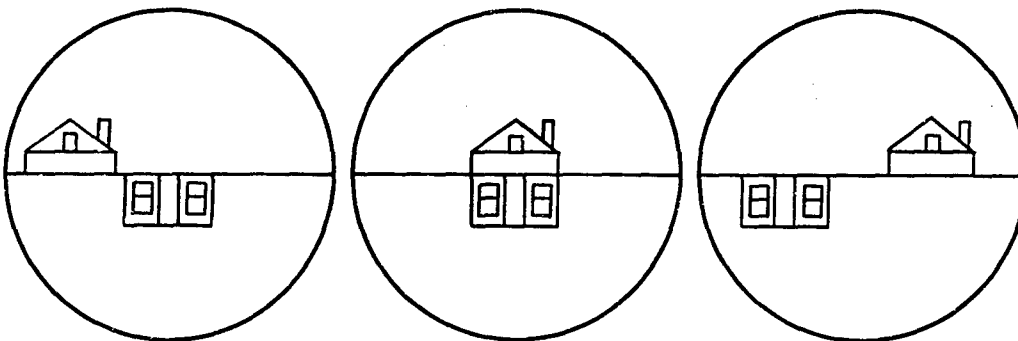


FIGURE A-3. SPLIT FIELD COINCIDENCE

e. Reticule Stadia - Stadia is the simplest form of triangulation ranging. In this method, the estimated target width becomes the base line of the triangle. The angle subtended by the target in the optical field of view is measured. As shown in Figure A-4, the target width (W meters) and the subtended angle (θ mils) are sufficient to solve for range (R meters). In practice the reticle is frequently designed to conform to selected, fixed-width targets such as 3 meters (width) and 6 meters (length) for tanks. The reticle is etched to provide automatically for superelevation when the target is fitted within the reticle lines. (See Fig. A-5)

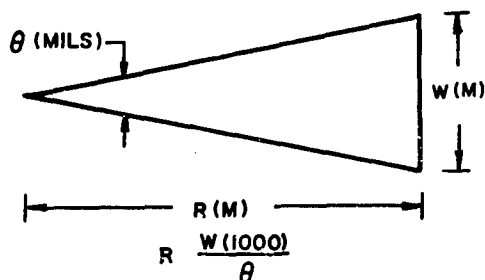


FIGURE A-4. STADIA COMPUTATION OF RANGE

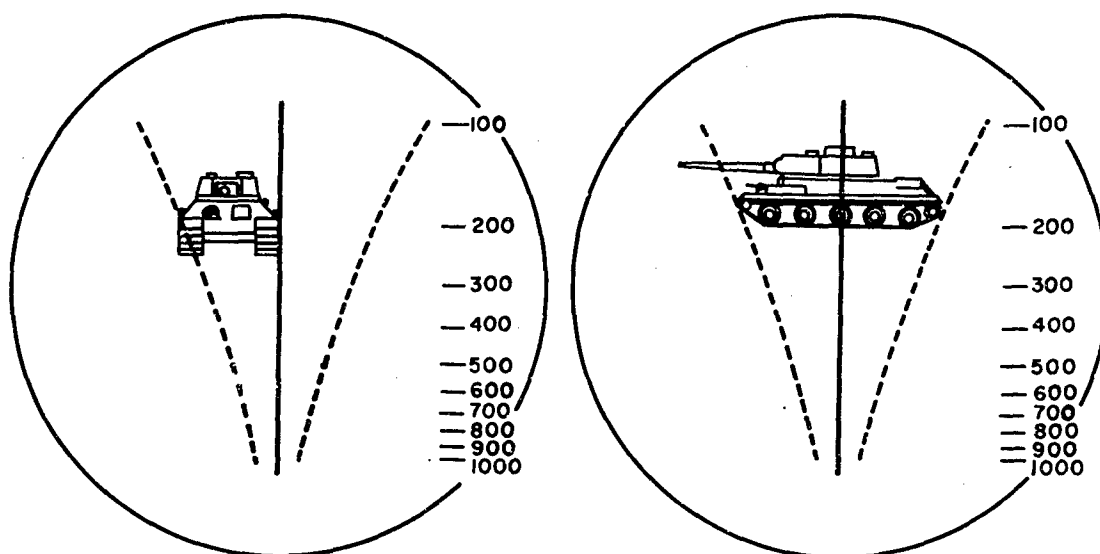


FIGURE A-5 RETICLE STADIA

f. Subcaliber Trajectory-Matching - The subcaliber trajectory-matching projectile incorporates a tracer and a spotter which functions on target impact. It acts as a range finder in that it is designed and biased to match the trajectory of a major caliber projectile. It need not report the range to the target as do devices discussed above, but it does indicate adjustments required in the weapon positioning to be able to hit the target. If the range value is desired, it may be read from the sight picture presented on a graduated, telescopic reticle. The unique advantage of this type of range finder lies in its ability to reflect the effect of wind, drift, and target movement on range accuracy as well as in its simplicity. Disadvantages in the ballistic matching problems are time and premature disclosure of firing position. An unmatched subcaliber trajectory of spotter-tracer projectiles may be used to determine range by having separate reticles for subcaliber and each primary gun-ammunition type. In this method, the subcaliber range must be

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sensed by the gunner, read from the subcaliber reticle, and transferred to the appropriate major caliber reticle. The gun may then be relaid and fired.

Since this procedure is concerned primarily with optical range finders, particularly as applied to tanks, no further discussion of subcaliber ranging is presented.

g. Radar and Pulsed Light - Electronic and pulsed-light ranging devices employ relatively elaborate electronic equipment to measure precisely the elapsed time between emission and return of either light or electromagnetic radiation pulses.

APPENDIX B

SELECTION OF OPERATORS

Pilot Models

On pilot model equipment, where time and the number of experimental samples are limited, it is seldom feasible to use as many operators as may be desired. For this reason, the initial testing period shall be accomplished with personnel skilled in the many aspects of tank gunnery; this minimizes training time and assures precise qualitative data.

If possible, the operator's vision should be normal and uncorrected by glasses. It is advisable to have periodic eye examinations administered to test personnel during the course of range finder evaluation to avoid overwork and subsequent eyestrain.

Training

Training times and techniques are important considerations in evaluating most military equipment. Careful records should be kept of instruction and practice time for each operator and any special training techniques employed which noticeably improve the operator's skill.

The operators should be given instructions on the proper use and adjustment of the equipment. Personal adjustments should be made and recorded for the following:

- a. Diopter Adjustment - Provides individual focus for each eye.
- b. Inter-Pupillary Adjustment - Provides adjustment for the inter-pupillary distance for the individual operator (usually from 58 to 72 millimeters).
- c. Halving - Permits vertical adjustment of the right and left field-of-view presentations. This is an instrument, rather than a personal adjustment.
- d. Internal Correction System (ICS) - Permits the operator to adjust the instrument to suit his own judgment of stereo contact and to compensate for large instrument variations. The operator should check his individual ICS setting frequently and maintain a record of his numerical values to establish a reliable, personal ICS setting to be used when operating range finders.

The element of time should be introduced into the ranging operation as soon as possible after the operator has acquired the ability to obtain consistent results with the instrument under test. The time required to obtain a range reading is important in combat, and experience has shown that an operator under training learns more rapidly when pressed for time; he gains confidence that precision range data can be obtained in short time intervals.

During data recording, the operator should not be advised continually on his performance, i.e., comparing individual range operations with the true range, lest the results be inadvertently biased.

Experience has shown that to become sufficient in the operation of the equipment, and obtain repeatable and precise results, a trainee requires from 200 to 2000 observations depending upon the type of instrument.